MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

PPH0056 – ELECTRICITY AND MAGNETISM

(Foundation in Engineering)

4 JULY 2023
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 7 pages (excluding the cover page) with 10 multiple choice questions in Section A and 4 structured questions in Section B.
2. Attempt **ALL** questions. The distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings **MUST** be shown.

SECTION A [10 marks]

1. When a previously uncharged object is charged to 1.602 μC,
   A. it has an excess of electrons
   B. 10^{13} electrons have been removed from it
   C. 10^{13} electrons have been added to it
   D. none of the above.

2. Two spheres are fixed near each other as shown in Figure A2. Each holds an identical charge $+q$ and experiences an electric force F. When a third sphere with a charge of $+2q$ is placed in the middle between them, the third charge will experience a net electrostatic force of magnitude.....
   A. 0
   B. $F/4$
   C. 1 F
   D. 2 F

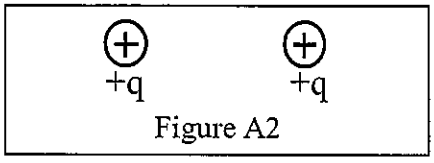


Figure A2

3. Which one of the properties of electric field lines is **not** true?
   A. The field lines always start on positive charges and end on negative charges.
   B. The direction of the electric field is always tangent to the field line at any point.
   C. Field lines never cross or touch.
   D. The number of lines leaving or entering a charge is proportional to the sign on the charge.

4. A point charge $+Q$ is located on the x axis at $x = a$, and a second point charge $-Q$ is located on the x axis at $x = -a$. A Gaussian surface with radius $r = 2a$ is centered at the origin. The flux through this Gaussian surface is
   A. zero because the negative flux over one hemisphere is equal to the positive flux over the other.
   B. greater than zero
   C. zero because at every point on the surface the electric field has no component perpendicular to the surface.
   D. zero because the electric field is zero at every point on the surface.

5. Two positive point charges are separated by a distance R. If the distance between the charges is reduced to $R/2$, what happens to the total electric potential energy of the system?
   A. It is doubled.
   B. It remains the same.
   C. It increases by a factor of 4
   D. It is reduced to one-half of its original value.

Continued...

6. Two parallel-plate capacitors are identical in every respect except that one has twice the plate area of the other. If the smaller capacitor has capacitance C, the larger one has capacitance

A. C/2 B. C C. 2C D. 4C

7. A parallel-plate capacitor is constructed using three dielectric materials, as shown in Figure A7

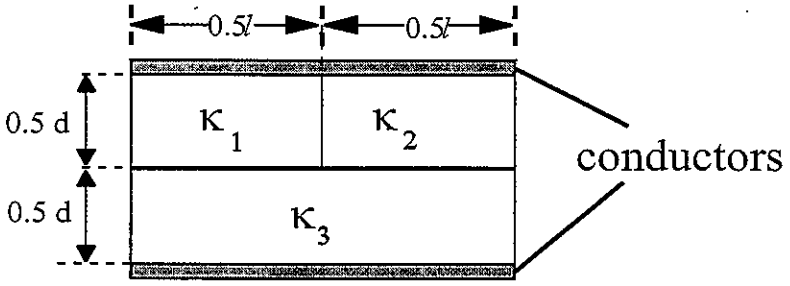
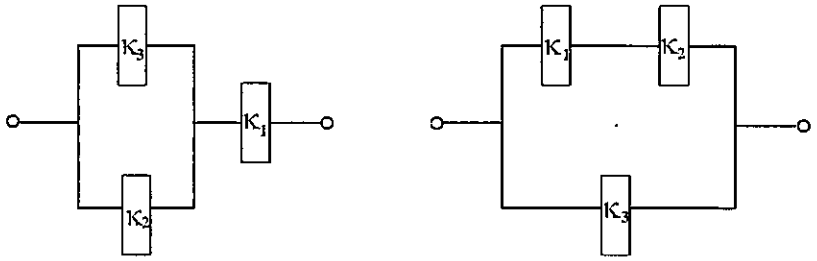


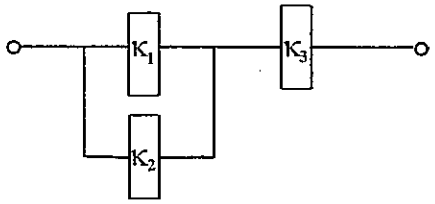
Figure A7

Which of the following circuits represents equivalent combination of capacitors in Figure A7?

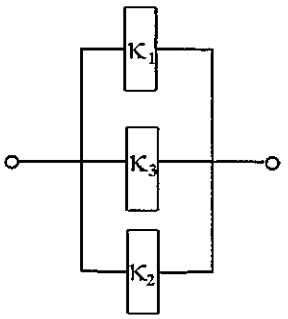


A.

B.



C.



D.

8. Using a 1 μF, 2 μF and 3 μF capasitor in combination, the least capacitance possible is

A. 1 μF B. 0.55 μF C. 0.5 μF D. 0.33 μF

Continued...

9. A parallel plate capacitor is first charged by connecting it to a battery and then the battery is disconnected. A dielectric slab is now inserted between the plates. Then,
   A. the charge remains constant.
   B. the voltage between the plates increases.
   C. the capacitance decreases.
   D. the energy stored in the capacitor increases.

10. A dielectric slab is inserted between the plates of parallel plate capacitor connected to battery, parallel to the plates. Then,
   A. some charge from the capacitor will flow into the battery.
   B. the voltage across the plates decreases.
   C. the voltage across the plates increases.
   D. the energy stored in the capacitor increases.

SECTION B [40 marks]

Question 1 [10 marks]

(a) A 5.50 A current flows through a copper wire of diameter 2.05 mm and through a light bulb. Copper has 8.5×10^{28} free electrons per cubic meter. Calculate

(i) the current density in the wire. [2 marks]

(ii) the drift velocity of electron in the wire. [2 marks]

(b)

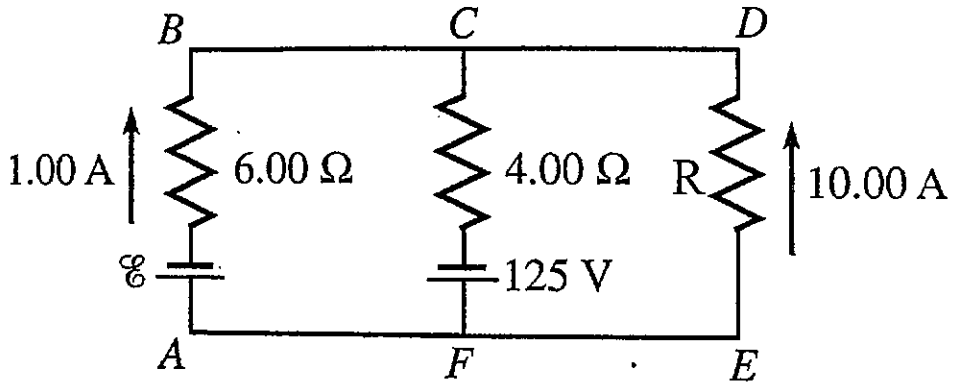


Figure B1b

Find the unknown emf and the unknown resistor in the circuit of Figure B1b. [6 marks]

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Question 2 [10 marks]

(a)

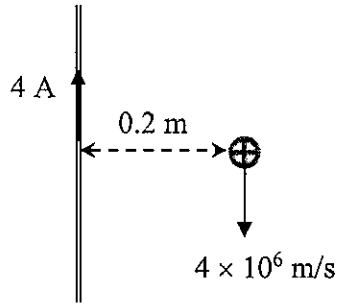

Figure B2a

Figure B2a shows a long straight wire carrying a current of 4 A. A proton travels at 4×10^6 m/s parallel to the wire 0.2 m from it and in the direction opposite to the current. Find,

(i) the magnetic field at the position of the proton. [2 marks]

(ii) the magnetic force experienced by the proton. [2 marks]

(iii) By redrawing the diagram, show what happens to the proton due to your answer in part (ii). [1 mark]

(b)

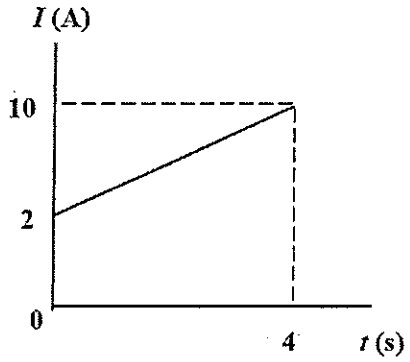

Figure B2b

A 6 cm long solenoid with 400 turns and cross-sectional area 7×10^{-4} m^2 experience a changing current as shown in graph in Figure B2b. Determine the

(i) induced emf. [3 marks]

(ii) magnetic flux through each turn at the instant when the current is 3 A. [2 marks]

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Question 3 [10 marks]

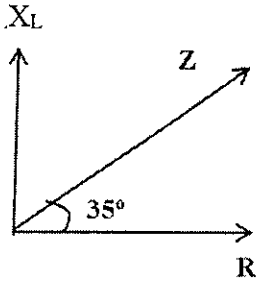

Figure B3

Figure B3 shows a phasor diagram of an RL series circuit connected to an AC source with rms voltage across the 0.8 H **inductor** of 62.8 V at 50 Hz and an unknown resistor. Determine the

(i) inductive reactance [2 marks]

(ii) rms current of the circuit [2 marks]

(iii) impedance, Z of the circuit [2 marks]

(iv) resistance, R of the resistor [2 marks]

(v) rms voltage of the circuit [2 marks]

Question 4 [10 marks]

(a) Briefly describe how charge carriers are generated and form current in semiconductor. [4 marks]

(b)

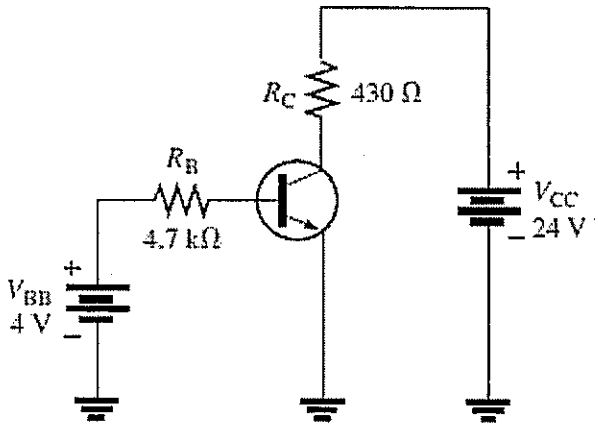

Figure B4b

Determine I_B, I_C and V_{CE} in Figure B4b. Assume silicone type bipolar junction transistor with $\beta = 50$. [6 marks]

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Physical Constants

Acceleration due to gravity	g	=	$9.8\ m\ s^{-2}$
Speed of Sound in Air	v	=	$343\ m\ s^{-1}$
Speed of light in vacuum	c	=	$3 \times 10^{8}\ m\ s^{-1}$
Threshold of hearing	I_0	=	$1.0 \times 10^{-12}\ W\ m^{-2}$
Coulomb constant	k	=	$9.0 \times 10^{9}\ N\ m^{2}\ C^{-2}$
Electronic charge	e	=	$1.602 \times 10^{-19}\ C$
Electron mass	m_e	=	$9.11 \times 10^{-31}\ kg$
Proton mass	m_p	=	$1.6726 \times 10^{-27}\ kg$
Neutron mass	m_n	=	$1.6749 \times 10^{-27}\ kg$
Refractive index of air/vacuum	n	=	1.0
Wein's displacement constant		=	$0.2898 \times 10^{-2}\ m.K$
Planck's constant	h	=	$6.626 \times 10^{-34}\ J.\ s$
Rydberg constant	R_H	=	$1.097 \times 10^{7}\ m^{-1}$
Avogadro's Number	N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Unified atomic mass unit	1 u	=	$1.66 \times 10^{-27}\ kg$
	1 eV	=	$1.602 \times 10^{-19}\ J$
Threshold of intensity of hearing	I_0	=	$1.0 \times 10^{-12}\ Wm^{-2}$
Stefan-Boltzmann constant	σ	=	$5.67 \times 10^{-8}\ J\ s^{-1}.m^{-2}.K^{-4}$
Universal gas constant	R	=	$8.31\ J\ mol^{-1}\ .\ K^{-1}$
Boltzmann's constant	κ	=	$1.38 \times 10^{-23}\ J\ K^{-1}$
	1 atm	=	$1.013 \times 10^{5}\ Pa$

The energy equivalent of the atomic mass unit is 931.494 MeV

Formula List

$$A_V = \frac{V_c}{V_b}$$

$$\propto_{dc} = \frac{\beta_{dc}}{\beta_{dc}+1}$$

$$\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}}$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \mu_0 nI$$

$$\xi = V + Ir$$

$$\xi = b\ell v$$

$$\xi = -N\frac{\Delta\Phi}{\Delta t}$$

$$\xi = -L\frac{dI}{dt}$$

$$\xi = -M\frac{dI}{dt}$$

$$F = BIL\sin\theta$$

$$F = Bqv\sin\theta$$

$$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$I_{tot} = \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$I = neA(v_n + v_p)$$

$$I = nev_dA$$

$$I = I_{\max}\sin\omega t$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

$$I_x = \left(\frac{R_T}{R_x}\right) I_T$$

$$L = \frac{N\Phi_B}{I}$$

$$L = \frac{\mu_0 N^2 A}{\ell}$$

$$M = \frac{N\Phi_B}{I}$$

$$M = \frac{\mu_0 N_1 N_2 A}{\ell}$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$P_t = I_{rms}V_{rms}\cos\phi$$

$$P_r = I_{rms}V_{rms}\sin\phi$$

$$P_a = I_{rms}^2 Z$$

$$R = \frac{\rho L}{A}$$

$$R = R_0[1 + \alpha(T - T_0)]$$

$$R_T = R_1 + R_2 + R_3 + \ldots$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

$$r = \frac{mv}{Bq}$$

$$\tau = BINA\sin\theta$$

$$U = \tfrac{1}{2} LI^2$$

$$u = \frac{1}{2}\frac{B^2}{\mu_0}$$

$$V_H = Bvd$$

$$V = V_{\max}\sin\omega t$$

$$V_{rms} = \frac{V_{max}}{\sqrt{2}}$$

$$V_x = \left(\frac{R_x}{R_T}\right) V_T$$

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi fL$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\oint B \cdot d\ell = \mu_0 I$$

$$d\mathbf{B} = \frac{\mu_0 I}{4\pi}\frac{d\ell \times \hat{\mathbf{r}}}{r^2}$$

$$\Phi_B = BA\cos\theta$$

$$\cos\phi = \frac{R}{Z}$$

$$\tan\phi = \frac{X_L - X_C}{R}$$